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Touch the comet! Testing of the "Rosetta's Comet Touchdown" educational kit in the Széchenyi István High School, Sopron, Hungary. Lang Á.[1], Bodnár L.[1], Ettingshausen M,[1], Majnovics Z.[1], Németh Á.[1], Sléber B.[1], Soós B.[1], Wesely N.[1] Roos M.[2] [1]Széchenyi István Gimnázium High School, H-9400 Sopron, Templom u. 26. Hungary (mmecurie95@gmail.com), [2]Lightcurve Films, Portugal (contact@lightcurvefilms.com)

Introduction: In our school works a course in robotics where students build and program robots from a LEGO MINDSTORMS kit. We took part in the Hunveyor-Husar project with a Mars rover based on a rover model kit, of which the operating arms are built out of LEGO and controlled by an MINDSTORMS NXT computer. We presented our rover on the EPSC in Rome last September 2010 We presented our rover on the EPSC in Rome in September 2010. At that same conference the "Rosetta's Comet Touchdown" educational kit was officially presented. We were very interested and in conversation with the people from the project, we agreed that our school in Sopron would also participate in testing the kit. . The kit comes with a set of Interdisciplinary Activity Sheets (IAS, downloadable from Vimeo channel[1]) and a great feature is that the proposed activities in the IAS cover three areas: science, art/history and engineering. The 31 students from our class divided up in groups and each group chose a different topic: History of comets in Hungarian culture; Designing a T-shirt; Research on comets; Hungary in the Rosetta mission; Animation of Rosetta's orbit in space; building a LEGO MINDSTORM model; a film was made of the activities .
In this presentation we report in particular the activities of the LEGO building team.

Overview: The LEGO team started to design, build and program a new landing unit. Although the demonstration model that is part of the Rosetta's Comet Touchdown kit is a perfect copy of the original and an

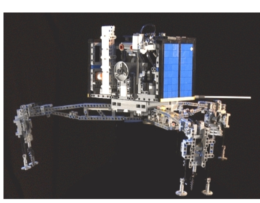
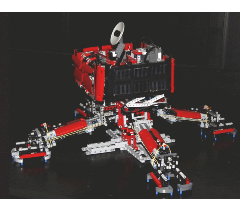



Fig. 1. The original LEGO lander *Fig. 2.Our lander*

almost perfect copy in terms of its functions, our students did not use it as a base. Instead, they followed their own ideas about how a lander should look like and they have designed, built and programmed a new landing unit. The legs that make a soft and safe landing possible are based on their own creative ideas. The cabin of the unit is square shaped instead of being hexagonal and all the sensors and probes are also designed by them. We received four boxes of LEGO-kits, with all the necessary elements and and the NXT computer from LEGO, but they did not contain sensors typical for Philae. So they were forced to build our own "original Hungarian" lander.

About Philae Lander: On arrival at the comet in 2014, Philae will be commanded to self-eject from the orbiter Rosetta and unfold its three legs, ready for a gentle touchdown. Philae will determine the physical properties of the comet's surface and subsurface and their chemical, mineralogical and isotopic composition. Philae may provide the final clues enabling the Rosetta mission to unlock the secrets of how life began on Earth.

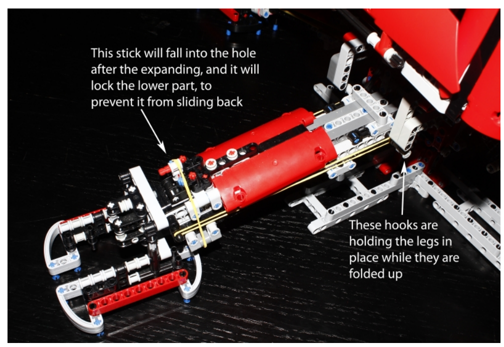


Fig. 3. The leg for the landing

The legs of our lander: Our legs are slightly different from the original ones. We have 4+1 legs. Four of them are long, and we also have a main holding leg in the

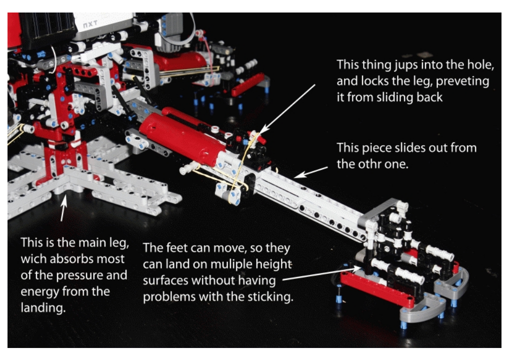


Fig. 4. The leg after the landig

middle.This leg absorbs all the pressure and energy from the fall. When the lander arrive to the comet, it folds up his legs, and when it hits the ground, the four legs fall down and expand. These legs have two main parts. One of them slides out from the other, this way can it expand to twice of its lenght.

Tasks and solves: What kind of tasks did we raise for our lander? How could we solve them? These two questions are – of course – related. We looked for tasks and focused on problems what we can solve from the LEGO elements and from our knowledge and mental background.

- measuring temperature. To this measurement we did not use the LEGO sensor, because that is big.. Instead, a semiconductor type thermometer was made compatible to our system. This means, it was fitted to the LEGO connector. We let down this sensor to the surface of the comet.
- measuring gases by a gas-sensor, so we may infer the chemical composition of the surface of the comet. The gas-sensor was fitted into the case of the sound sensor, in this way it was made compatible to the LEGO system. Using a laser beam to heating we liberate gases from the frozen surface of the comet, for the gas sensor measurements. Our gas sensor identifies water vapour, CO_2, H_2, and CH_4 . We let down this sensor to the surface of the comet, too.
- measuring the surface gravity, by an instrument which is a very specific development (we describe it later).
- measuring surface magnetic field using an original LEGO compass.

Besides these measurements we installed a wireless camera which relay the images to the orbiter. After landing the cabin turns around its central leg in order to the panorama images for the camera looking around. (The camera is placed in a fixed position inside the cabin, so it can not turn around individually, only with the cabin itself.)

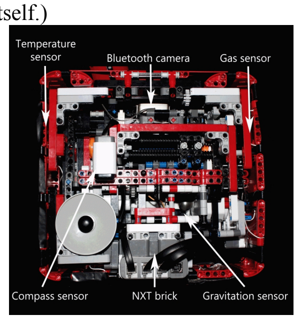
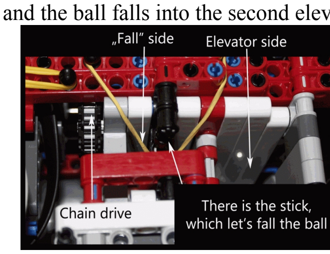


Fig. 5.The sensors of our lander

Motions: In order to carry out these measurements the following motions are necessary: opening the shield of the camera; turning around the cabin with 360°; opening a parabola antenna (symbolic step); operating the trigger of the gravimeter.. We must let down to the surface the thermal sensor and the gas-sensor .

We had some problems with the fact that the NXT has maximum 3 motorport and we should operate 6 motors. Our solution was that we use one port for the rotation of the cabin, while by the other 2 motors we operate 7 different transmission systems. The operation of the multiplexor is simple, however, to make it was not an easy task. The driven gears are connected with the suitable systems by the other motor.

Our LEGO g-meter: The theoretical basis of the measurements is the free fall formula, but we planned an instrument which can be used in a repeated measurement/ fall experiment carried out with the same body. In order to do this, the fallen body should have been returned to the initial position. That is why the instrument for measuring gravity consists of two „elevator shafts". In the first one the ball is lifted up, and when the lift with the ball arrives out from the elevator shaft, it tiltes and the ball falls into the second elevator shaft.



There an arm grips the ball. When the motor drives the arm, the arm tiltes and the ball falls down. At the bottom the ball falls onto an other arm, which presses down the touch sensor. The NXT measures the time between the tilting of the upper arm till the pressing the touch sensor. From this time it calculates the surface gravity of the cometary body. ($g=2s/t^2$). After the process, the ball rolles into the first elevator shaft, and the experiment can be repeated again.

. **Summary:** We report testing "Rosetta's Comet Touchdown" project in Széchenyi High School; the work of the participiants and in particular the activities of the LEGO building team. The planning/building/programming problems gave great tasks for high school students, but they enjoyed the work and learned very much.

References: [1]The official site of the project is www.vimeo.com/channels/rosettascomettouchdown.

Acknowledgements: Thank LEGO MINDSTORMS for material support